213831.00003 PATENT APPLICATION

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of:	)	
	:	Examiner: Tuan M. Nguyen
NIMA AHMADVAND, ET AL.	)	
	:	Group Art Unit: 2828
Application No.: 09/863,417	)	
	:	
Filed: May 24, 2001	)	
	:	
For: MULTI-WAVELENGTH LASERS	)	February 5, 2003

Commissioner for Patents
Washington, D.C. 20231

CLAIM TO PRIORITY

Sir:

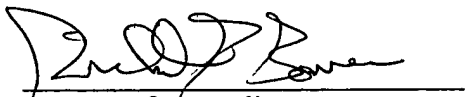
Applicants hereby perfect their claim to priority under the International Convention and all rights to which they are entitled under 35 U.S.C. § 119 based upon the following Canadian Priority Application:

2,310,199, filed May 29, 2000

A certified copy of the priority document is enclosed.

Applicants' undersigned attorney may be reached in our Washington, D.C. office by telephone at (202) 625-3500. All correspondence should continue to be directed to our address given below.

Respectfully submitted,



Attorney for Applicants

Registration No. 31,588

PATENT ADMINISTRATOR
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Doc #:DC01 (13831-00001) 4102259v1;7/20/2001/Time:15:03

Doc #:WAS01 (213831-00003) 41379109v1;2/5/2003/Time:14:12

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3-17-03

Bureau canadien des brevets

Certification

Canadian Patent Office

Certification

La présente atteste que les documents ci-joints, dont la liste figure ci-dessous, sont des copies authentiques des documents déposés au Bureau des brevets.

This is to certify that the documents attached hereto and identified below are true copies of the documents on file in the Patent Office.

Specification and Drawings, as originally filed, with Application for Patent Serial No: **2,310,199,** on May 29, 2000, by **TELLAMON PHOTONIC NETWORKS INC.,** assignee of Nima Ahmadvand and Hamid Hatami-Hanza, for "Multi-Wavelength Lasers".

S. Gregoire

Agent certificateur/Certifying Officer

October 11, 2002

Date

Canada

(CIPO 68)
04-09-02

OPIC CIPO

ABSTRACT

In this invention an optical gain element is used where a fraction of the optical output signal is passed through a periodic filter and fed back to the gain medium. This configuration simply forms a multi-wavelength ring laser. The optical gain element provides the gain medium for the laser and the filter forces the laser to lase on the predetermined wavelengths. The periodic filter can simply be an asymmetric Mach-Zehnder interferometer (MZI). It is known that asymmetric MZIs have an almost sinusoidal wavelength response where its period is a function of the length difference of the arms of the asymmetric MZI. In other words, one can control the channel spacing by changing the length difference of an Asymmetric MZI.

MULTI-WAVELENGTH LASERS

FIELD OF INVENTION

This invention generally relates to optical communication systems and more particularly optical laser sources with multiple lasing wavelengths.

BACKGROUND

One way to utilize the large bandwidth of optical fibers is to use optical wavelength division multiplexing (WDM) schemes to increase the rate of data transmission through optical fibers. In the transmitter end of a WDM transmission systems and network one has to have a number of laser sources with different wavelengths. Each laser light then is modulated either directly in the laser or by an external modulator to impress the data information on each of the WDM channels.

Multi-wavelength laser sources are desirable for optical wavelength division multiplexed (WDM) transmission systems and networks.

US patent 5, 910, 962 introduces a multi-wavelength laser source that can provide multiple laser signals at different wavelengths incorporating DBR (Distributed Bragg Reflector) fiber lasers or DFB (Distributed Feedback) fiber lasers. In the proposed design, a pumping laser with operating wavelength below 1500 nm is used. Each DFB or DBR laser is tuned to a selected wavelength in the 1550 nm range. The fiber lasers may be connected in series to each other to form a multi-

wavelength source. There are a number of issues with respect to this arrangement. We can easily observe that the number of wavelength channels is very limited. As a result, it is very difficult to scale the source to have a large number of lasing channels. On the other hand, the tuning of each laser and consequently the whole set of wavelength channels are very challenging processes. Stability of the lasing frequencies is also of great concern.

M. Zirngibl et al. ["An 18-channel Multi-Frequency Laser," *IEEE Photonics Technology Letters*, Vol. 8, No. 7, July 1996] propose an array of semi-conductor optical amplifiers integrated monolithically with a WDM multiplexer/demultiplexer. In this architecture, a Wavelength Grating Router (WGR) is used as an intra-cavity wavelength selective filter element. The number of amplifiers and the complexity of the WDM filter increase as we increase the number of lasing channels, or equivalently decrease channel spacing in a given wavelength range. The wavelength selectivity of this device is governed by the geometric layout of the filter and a discrete choice of the gain elements. As a result, for a large number of wavelength channels, a large number of router arms are needed. The cost of these multi-wavelength laser sources therefore is high and they cannot be easily fabricated for a large number of wavelength or lasing channels. Similar designs also have been reported, such as R. Monnard et al. ["Direct Modulation of a Multi-frequency Laser up to 16 x 622 Mb/s," *IEEE Photonics Technology Letters*, Vol. 9, No. 6, June 1997].

It is very desirable to have a low cost multi-wavelength laser source with a large number of lasing channels.

SUMMARY OF THE INVENTION

In this invention an optical gain element is used where a fraction of the optical output signal is passed through a periodic filter and fed back to the gain medium. This configuration simply forms a multi-wavelength ring laser. The optical again element provides the gain medium for the laser and the filter forces the laser to lase on the predetermined wavelengths. The periodic filter can simply be an asymmetric Mach-Zhender interferometer (MZI). It is known that asymmetric MZI have an almost sinusoidal wavelength response where its period is function of the length difference of the arms of the asymmetric MZI. In other words, one can control the channel spacing by changing the length difference of an Asymmetric MZI.

BRIEF DESCRIPTION OF THE FIGURES

Figure 1 presents the general structure of the multi-wavelength laser source introduced by this invention.

Figure 2 illustrates the multi-wavelength laser source with EDFA.

Figure 3 shows a typical transfer function for a periodic Mach-Zehnder band-pass filter.

Figure 4 shows the spectrum of the output signal of a multi-wavelength laser source for a ring laser using 3.5m EDF.

Figure 5 displays the spectrum of the output signal of a multi-wavelength laser source for a ring laser using 10m EDF.

Figure 6 shows a multi-wavelength laser source with Gain Flattened EDFA.

DETAILED DESCRIPTION

This invention introduces a novel multi-wavelength laser source design with the general configuration shown in Figure 1. In this typical configuration, a fraction of the optical output signal of an optical gain module is filtered and fed back to the gain medium. When there is no input signal to the gain module, the output of the module is referred to as the "free run" output. Any optical amplifier may be used for the gain module. In the following, Erbium Doped Fiber Amplifier (EDFA) is used for the gain module. Figure 2 shows the main architecture with EDFA. The free run output of the EDFA is known as Amplified Spontaneous Emission (ASE) that is always present and usually treated as amplifier noise.

As shown in Figure 2, a fraction of the ASE output (free run signal) of the EDFA is filtered and fed back to the EDFA. If a relatively narrow band-pass filter (BPF) is used for the filter, the EDFA starts lasing in a frequency around central frequency of the BPF. This architecture is also known as "Ring Laser." Ring lasers have already been used in the optical systems. In this invention, a novel cost efficient multi-wavelength laser source is built using the same principles.

Here we look into more details of the multi-wavelength laser source based on EDFA shown in Figure 2. In the gain module, Erbium Doped Fiber (EDF) forms the gain medium. The pump laser, which is usually a 980 nm laser, provides the optical power for the gain medium. The pump laser output is coupled into the EDF by a WDM coupler. At the output of the gain module a 2 x 2 optical coupler is used to take a fraction of the output signal out to be fed back to the gain module. The other output port of the coupler provides the output of the laser source. In the configuration shown, the output is connected to an Optical Spectrum Analyzer (OSA). In the feedback path, the optical signal is filtered through a periodic filter, such as a Mach-Zehnder Interferometer (MZI) filter. This filter has a periodic filter shape that forces the gain module to concentrate its energy in specific frequency (wavelength) bands and consequently to lase in those bands. A typical transfer function of such a filter is shown in Figure 3. In an ideal case, it is expected that one lasing source to be observed in each band-pass of the filter. This is basically true if the gain profile of the gain module is flat in all through the frequency band of interest. Unfortunately, an EDFA does not have a flat gain transfer function. Consequently, lasing would be observed only in some of the desired wavelength channels as shown in Figures 4 and 5. Figure 4 shows the multi-wavelength laser source output observed by the OSA for the case of 3.5 m EDF and 120 mW pump power. In this case, five different lasing signals were detected. Once we increased the EDF length to 10 m, seven laser sources were observed at the different locations than those of the previous case. This shown in Figure 5. Since the gain profile of

the EDFA is not flat, the lasing channels were observed in the wavelength range that has the maximum gain. In the example shown in Figure 4, the lasing appears mainly around the high gain region of the 1530 nm. However, as we increase the length of the EDF, another lasing region around 1550 nm is also observed. This is mainly because of the fact that for longer EDF there are two high gain regions of 1550 nm and 1530 nm. The 1550 nm region is the dominant one. In figure 5, we can clearly see that the number of lasing channels in 1550 nm region is more than that of 1530 nm region.

In order to increase this number, a gain flattening filter (GFF) is added to the previous design. This architecture is shown in Figure 6. This helps to reduce the competition among different band-pass of the periodic BPF and to distribute pump energy to all the desired band-pass uniformly. As a result, a multi-wavelength laser source can be realized.

In the design of a practical multi-wavelength laser source some other issues must be taken care of. The BPF needs to be stable to enable lasing in the band-passes as well as stable lasing channels. Some forms of polarization control might also be needed in the feedback loop to enhance effective feedback of the signals in all the band-passes.

The proposed architecture in this invention has other advantages over other multi-wavelength laser sources introduced in the literature. Some of those are its simplicity, scalability and potentially low price.

Note that the number of lasing channels in the frequency band of interest, where the gain module has a flat gain profile, is simply determined by the periodic BPF. An option for the periodic BPF filter is the MZI filter, which is not very expensive. The periodic BPF (e.g. MZI filter) may be tuned to ITU frequency grid to form a standard multi-wavelength laser source.

WHAT IS CLAIMED:

1. A multi-wavelength laser, comprising:

(a) a pump laser source;

(b) an optical gain module (OGM) for receiving the output of the laser sources;

(c) a periodic band-pass filter (PBF) in a feedback loop between output and input of the optical gain module; and

(d) the output of the OGM being an output of said multi-wavelength laser.

2. The multi-wavelength laser as defined in claim 1, said OGM including a gain flattening filter (GFF) between it and said periodic BPF.

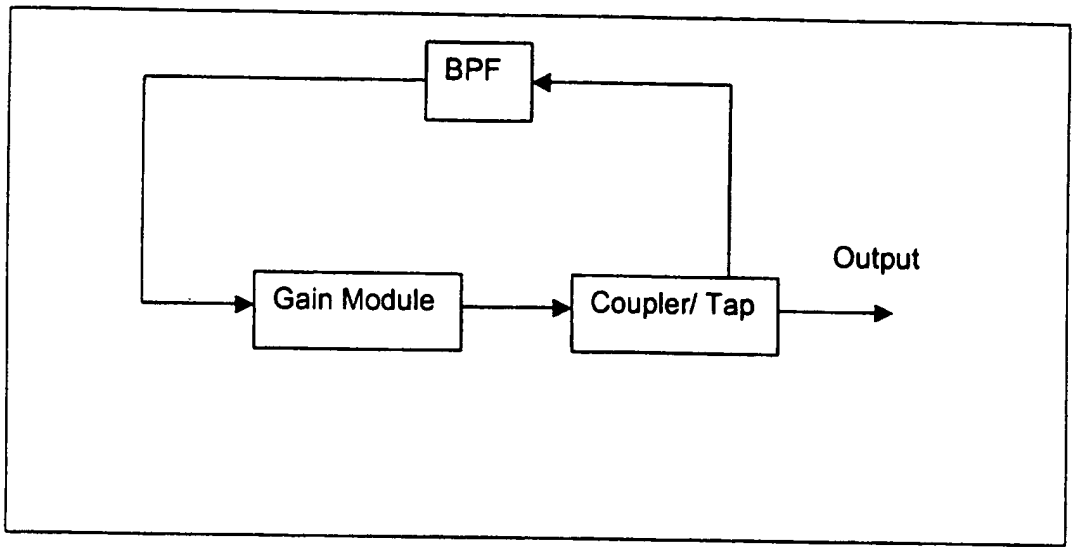

Figure 1. General Structure

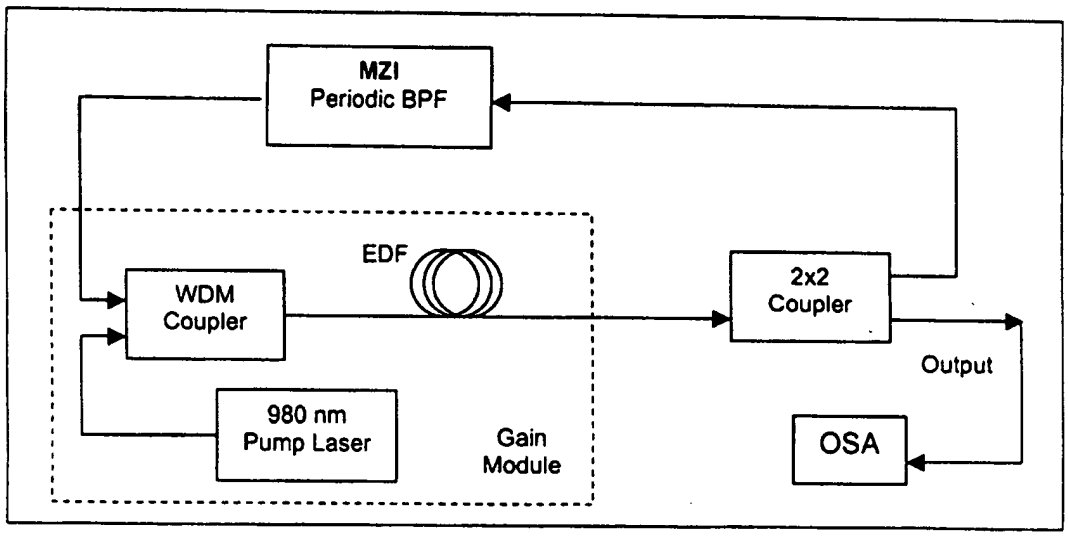

Figure 2. Ring Laser Using EDFA

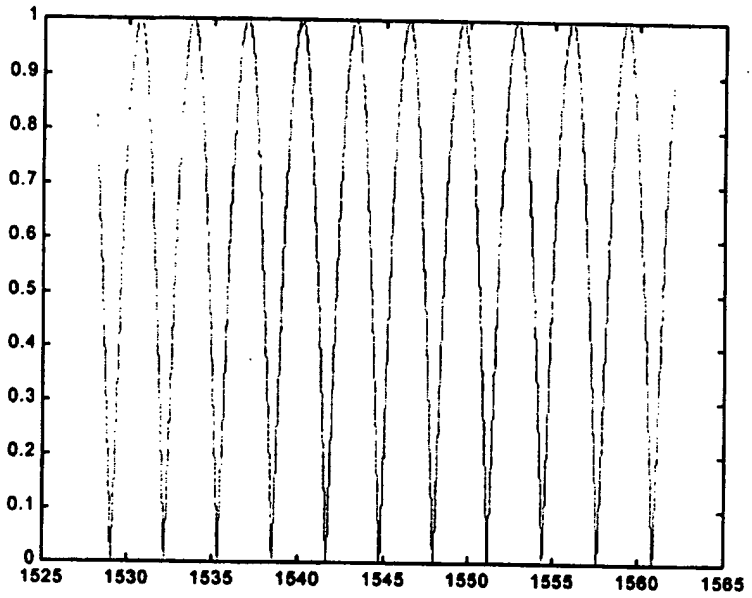

Figure 3. Typical Normalized Response of a Periodic MZI Filter

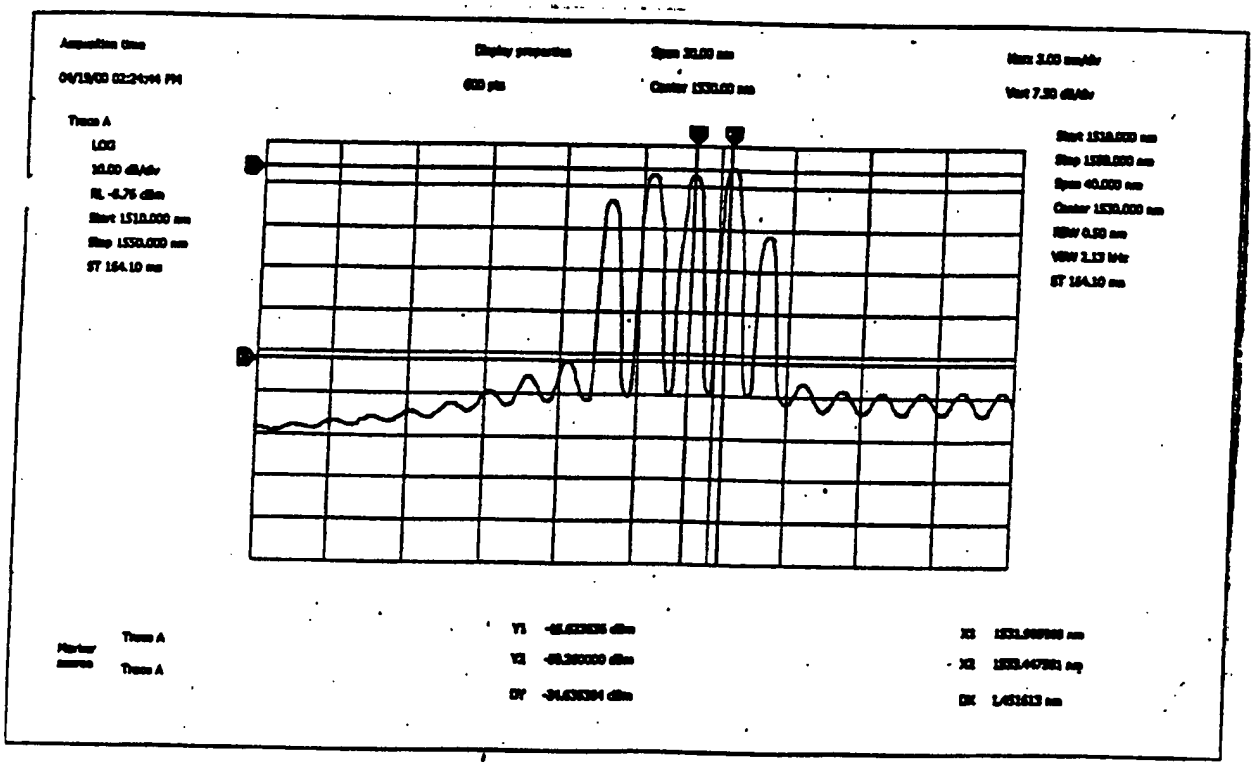

Figure 4. Output Spectrum of the Multi-wavelength laser Source with 3.5m EDF

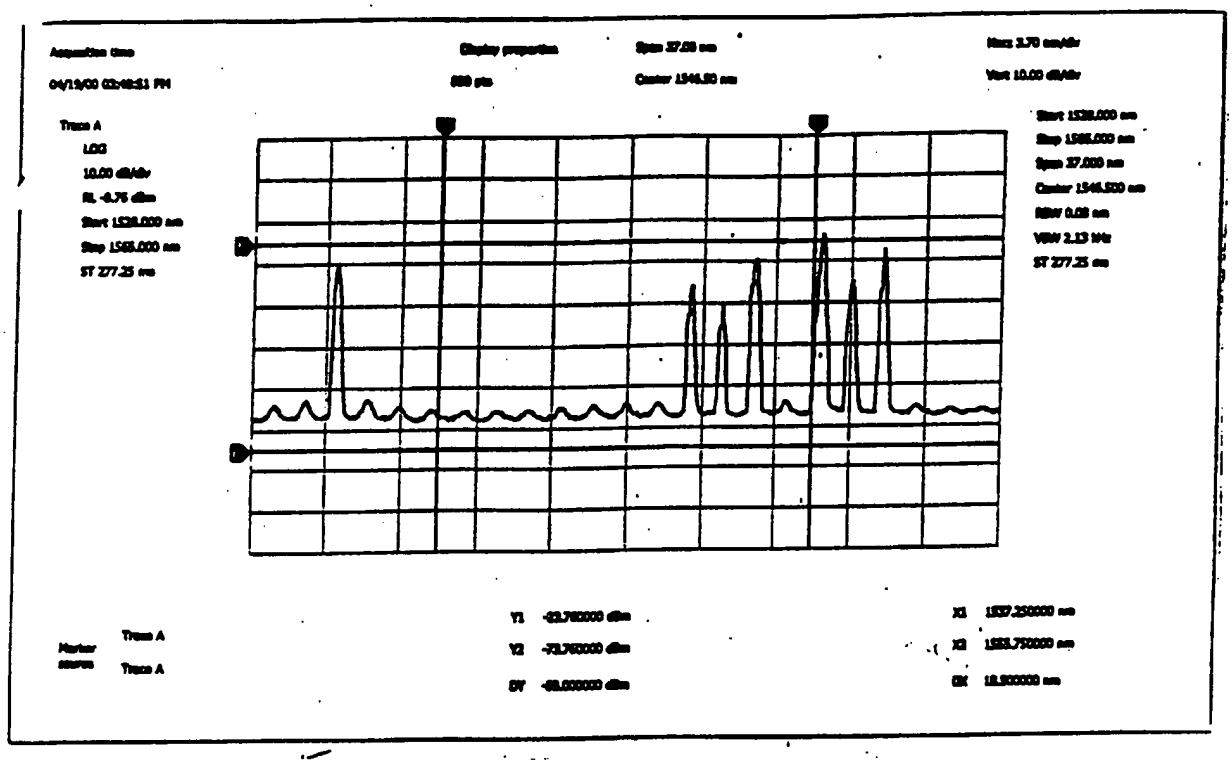

Figure 5. Output Spectrum of the Multi-wavelength laser Source with 10m EDF

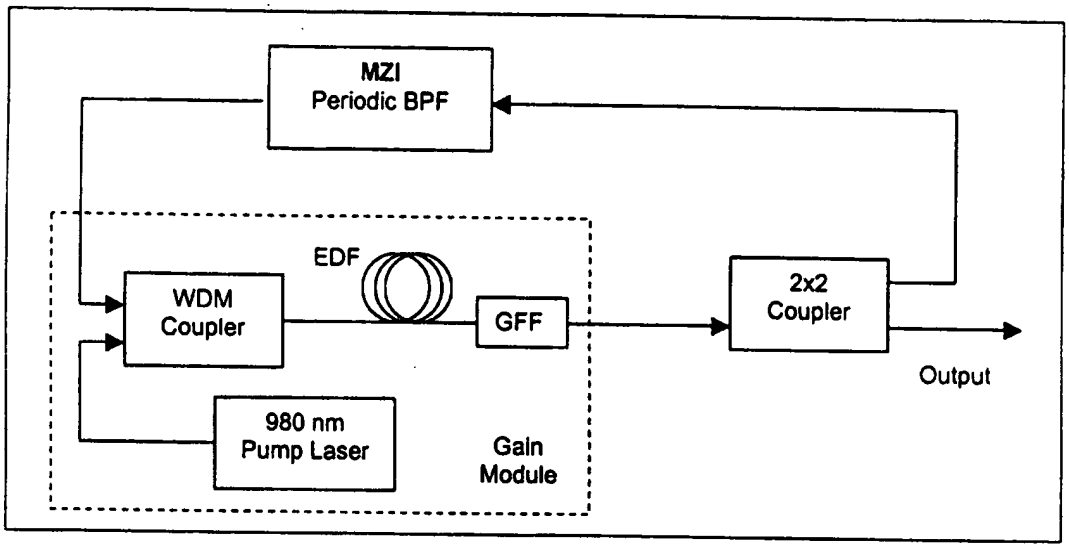

Figure 6. Multi-wavelength laser source with Gain Flattened EDFA

FORM-PTO-1595 TRANSMITTAL OF DOCUMENT FOR RECORDATION
1-31-92 PATENTS ONLY Atty. Docket: 213831.00003

To the Commissioner of Patents and Trademarks: Please record the attached original documents or copy thereof.

1. Name of conveying party(ies):

TELLAMON PHOTONIC NETWORKS, INC.

Additional name(s) of conveying party(ies) attached?
☐ Yes ☒ No

2. Name and address of receiving party(ies):

Name: PELETON PHOTONIC SYSTEMS INC.

Foreign Address: 2280 Walkley Road

Ottawa, Ontario, Canada K1G 6B1

Additional name(s) & address(es) attached? ☐ Yes ☒ No

3. Nature of conveyance:
☐ Assignment ☐ Merger
☐ Security Agreement ☒ Change of Name
☐ Other

Execution Date: June 6, 2001

4. Application number(s) or patent number(s): 09/863,417
If this document is being filed together with a new application, the execution date of the application is: _____

A. Patent Application No.(s)

B. Patent Registration No.(s)

Additional numbers attached? ☐ Yes ☒ No

5. Name and address of party to whom correspondence concerning document should be mailed:

Name: Katten Muchin Zavis Rosenman, Patent Admin.

525 West Monroe Street, Ste. 1600

Chicago, Illinois 60661-3693

Telephone No.: (312) 902-5200

Facsimile No.: (312) 902-1061

6. Number of applications and patents involved: One

7. Total fee (37 C.F.R. § 3.41): $ 40.00

☐ Enclosed
☒ Authorized to be charged to Deposit Account.

8. Deposit Account Number: 50-1710

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9. Statement and signature.

To the best of my knowledge and belief, the foregoing information is true and correct and any attached copy is a true copy of the original document.

Richard P. Bauer, Reg. No. 31,588
Name of Person Signing


Signature

February 5, 2003
Date

Total number of pages including cover sheet, attachments, and documents: 5

FORM-PTO-1595 1-31-92	TRANSMITTAL OF DOCUMENT FOR RECORDATION PATENTS ONLY	Atty. Docket: 213831.00003

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Richard P. Bauer, Reg. No. 31,588		February 5, 2003
Name of Person Signing	Signature	Date

Total number of pages including cover sheet, attachments, and documents: 5

Industry Canada | Industrie Canada

Certificate of Amendment

Certificat de modification

Canada Business Corporations Act

Loi canadienne sur les sociétés par actions

PELETON PHOTONIC SYSTEMS INC.

328098-5

Name of corporation-Dénomination de la société

Corporation number-Numéro de la société

I hereby certify that the articles of the above-named corporation were amended:

Je certifie que les statuts de la société susmentionnée ont été modifiés:

a) under section 13 of the *Canada Business Corporations Act* in accordance with the attached notice;

☐ a) en vertu de l'article 13 de la *Loi canadienne sur les sociétés par actions*, conformément à l'avis ci-joint;

b) under section 27 of the *Canada Business Corporations Act* as set out in the attached articles of amendment designating a series of shares;

☐ b) en vertu de l'article 27 de la *Loi canadienne sur les sociétés par actions*, tel qu'il est indiqué dans les clauses modificatrices ci-jointes désignant une série d'actions;

c) under section 179 of the *Canada Business Corporations Act* as set out in the attached articles of amendment;

☑ c) en vertu de l'article 179 de la *Loi canadienne sur les sociétés par actions*, tel qu'il est indiqué dans les clauses modificatrices ci-jointes;

d) under section 191 of the *Canada Business Corporations Act* as set out in the attached articles of reorganization;

☐ d) en vertu de l'article 191 de la *Loi canadienne sur les sociétés par actions*, tel qu'il est indiqué dans les clauses de réorganisation ci-jointes;

Director - Directeur

June 7, 2001 / le 7 juin 2001

Date of Amendment - Date de modification

Canada

MINUTES of a Special Meeting of the Shareholders of TELLAMON PHOTONIC NETWORKS INC. held on the 6th day of June, 2001, at the hour of 2:00 o'clock p.m.

CHAIRMAN AND SECRETARY

Hamid Hatami-Hanza acted as Chairman and Paul Salvatore acted as Secretary of the meeting.

APPOINTMENT OF SCRUTINEER

The Chairman, with the approval of the meeting, appointed Peter Okulich to act as scrutineer of the meeting.

NOTICE AND CONSTITUTION

The Chairman advised the meeting that the notice calling the meeting and the accompanying form of proxy were mailed and sent to all shareholders of the Corporation and that additional copies of these materials were available at the meeting. With the consent of the meeting, reading of the notice of the meeting was dispensed with.

QUORUM

The scrutineer advised the Chairman that the requisite quorum of shareholders was present either in person or by proxy and the Chairman declared the meeting to have been regularly called and properly constituted for the transaction of business. The Chairman directed that the report of the scrutineer be annexed to the minutes of the meeting.

AMENDMENT TO ARTICLES

The Chairman stated that the special meeting of the shareholders had been called for the purpose of considering and, if thought advisable, passing, with or without amendment, a special resolution of the Corporation authorizing an amendment to the articles of the Corporation to change the name of the Corporation to Peleton Photonic Systems Inc.

On motion made, seconded and unanimously carried, it was RESOLVED THAT the articles of the Corporation are hereby amended to change the name of the Corporation to Peleton Photonic Systems Inc.

TERMINATION

There being no further business, on motion the meeting then terminated.

Chairman

Secretary

CANADA BUSINESS CORPORATIONS ACT

FORM 4

ARTICLES OF AMENDMENT (SECTION 27 OR 171)

1 - Name of corporation	2 - Corporation No.
TELLAMON PHOTONIC NETWORKS INC.	3280985

3 - The articles of the above-named corporation are amended as follows:

to change the name of the Corporation to PELETON PHOTONIC SYSTEMS INC.

Date	Signature	Title
June 6, 2001		President & CEO

Filed

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